

ABSTRACT

A hydraulically-actuated unit fuel injector of the intensifier type is provided with two independently operable active control valves. A selectively actuatable fuel pressure control valve is disposed on the hydraulic actuation fluid side to control the fuel pressure actuation process and provide a window of injection opportunity wherein the fuel pressure is maintained at high pressure. A selectively actuatable timing control valve is disposed on the high pressure fuel side to provide precise control of injection timing events and duration, such as start of injection, end of injection, timing of interruption and duration of interruption, which all may occur during a single injection event within the window of opportunity. The timing control valve may take various forms including piezo controlled direct needle actuation valves and common rail injector needle control valves. Both control valves are independently controlled to prevent reverse motion of the intensifier piston and plunger during dwell or interruption of injection while maintaining the full injection pressure. Dwell or interruption is controlled by using the timing control valve to port fuel under pressure to a fuel injector needle valve surface to generate a force on the fuel injector needle valve surface acting to close the fuel injector needle valve. Methods of defining a fuel injection event fuel injector having a fuel pressure intensifier, includes the steps of (a) preparing fuel pressure with a fuel injection pressure control valve, and (b) controlling the timing of a fuel injection event with a fuel injection timing control valve, the fuel pressure preparation and the timing of the fuel inject event being independently controllable. Preferably, full intensified fuel pressure is made available to the injector throughout a single injection event which may include a pilot injection, a main injection, a rate-shaped injection, and dwell periods wherein no injection occurs. Various methods of operating the fuel injector to provide various functions during a single injection event are also disclosed.